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Comparative Fishing Trials with Shrimp Nets

1954-1956

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INTRODUCTION

In the summer of 1950 and during the two subsequent years, when regular trips on various shrimping boats in the Thames area were made, with the aim of collecting samples of pink shrimps (*Pandalus montagui* Leach), the author was impressed by the quantities of non-commercial shrimps caught.

The percentage of non-commercial pink shrimps varied according to the season, being low in May, June and at the beginning of July, but rising after the middle of July, when the 0-group shrimps entered the catches. Since all the existing mesh-size nets were catching small shrimps, it seemed obvious that the introduction of a larger mesh would limit the destruction of non-commercial shrimps and at the same time would reduce considerably the labour and time taken in riddling the catch.

Various investigators (Hjort and Ruud, 1938; Roelofs, 1950; Rasmussen, 1951; Havinga, 1951a, 1951b; Gilis, 1952a, 1952b; Cole, 1956), have discussed the question of undersized shrimps or prawns captured by the trawl nets used. Hjort and Ruud, Roelofs and Gilis, who tried nets with different mesh-sizes and measured the quantities of small prawns or shrimps caught, all observed that a larger mesh-size net catches smaller percentages of small prawns or shrimps. Nevertheless, even the nets with a comparatively large mesh retained some immature shrimps.

On the trips referred to, the small shrimps were eventually returned to the sea after the riddling process, but by the time the catch was sorted out from the various fish, crabs, shells and seaweeds, most of the shrimps appeared to be dead. It was also observed that the pink shrimp, unlike the brown shrimp (*Crangon vulgaris* L.), succumbed quite quickly when taken out of the water. Riddling regulations, such as are in force in many areas would, therefore, perhaps be less effective for conservation of pink shrimps.

Release by larger mesh and survival on return to the water were therefore investigated and are reported on below.

FLUCTUATIONS OF THE SHRIMP FISHERIES

During the past 45 years the annual landings of shrimps in England and Wales fluctuated between 17,500 and 73,000 cwt., or approximately between 900,000 and 3,700,000 kgs. (Fig. 1). Certain distinct falls in landings may have been due to the reduced fishing effort during the war years and immediately after, and to the severe winters of 1928-29, 1939-40, and 1946-47. Even if these exceptionally poor years are not taken into consideration, on the whole the landings during the past 25 years were smaller than for the period 1910 to 1930. Whether reduction in landings is the result of a decline in the stock, or of reduced fishing effort, it is difficult to determine. There are no available data with regard to the number of boats and men engaged in the shrimp fishery. It is known, however, that after World War I the shrimping fleet decreased gradually. Moreover, the official landings are the combined figures of brown and pink shrimps, so that no definite conclusion can be derived for the fluctuations of one particular fishery. Consequently if there is a failure of the pink shrimp fishery, this may not be obvious, due to substantial landings from the brown shrimp fishery. This feature can be observed when analysing the landings from the most important producing areas. Landings of brown and pink shrimps at ports in the Wash, Thames area and Morecambe Bay amount approximately to 80% of the total landings.

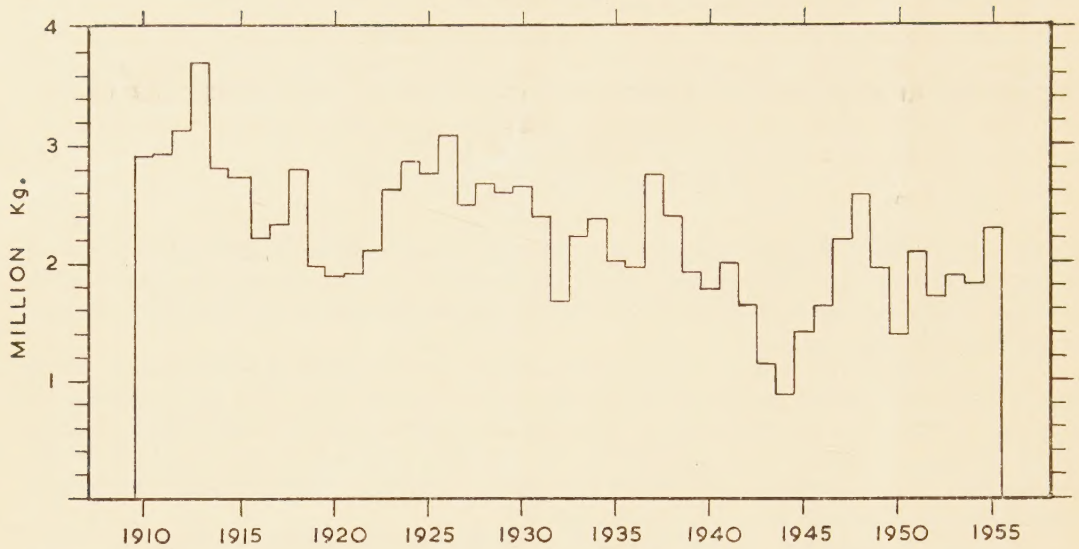

Fig. 1. *Landings of pink and brown shrimps in England and Wales for the years* 1910 *to* 1955.

The pink shrimp, which is associated with a distinct type of sea bottom (Mistakidis, 1957), is found in considerable densities in the Wash, Thames area and, until recently, in the Lune Deep, Morecambe Bay. In the Wash, where landings at three ports, Boston, Fosdyke and King's Lynn, vary between 35 and 50% of the total landings for England and Wales, the shrimping fleet fishes both the pink and brown shrimps. The Boston shrimp boats are bigger than the remainder of the fleet, and concentrate more on fishing the pink shrimps, which are found on grounds at some distance from land. Accordingly any fluctuation of the pink shrimp fishery will be more marked in landings at Boston than at King's Lynn or Fosdyke (Fig. 2).When pink shrimps were very scarce during 1949 and

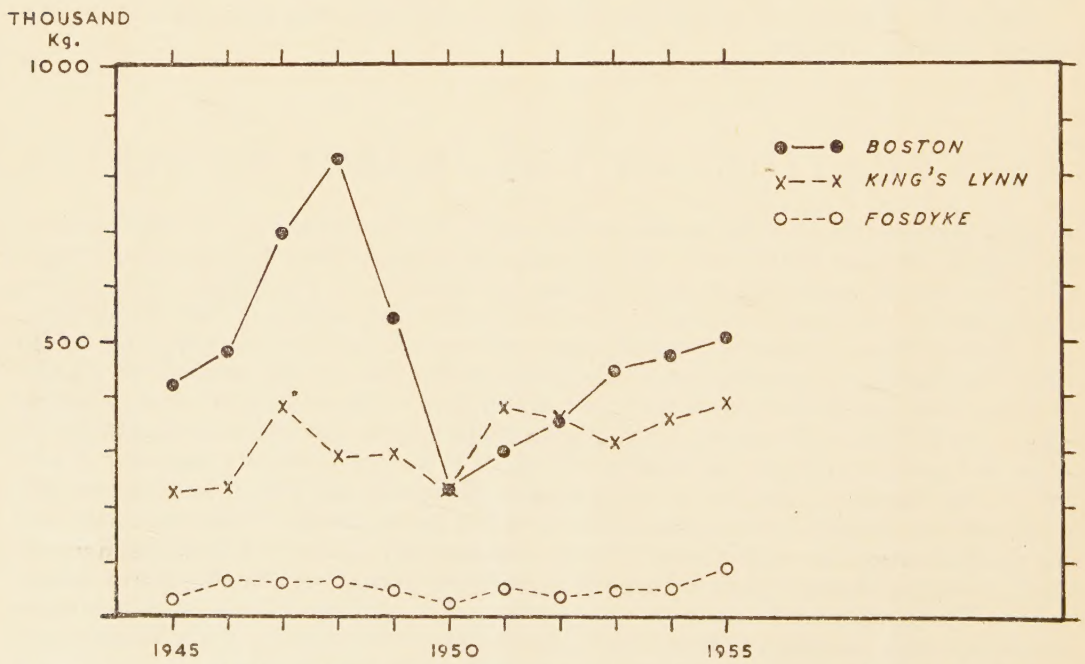

Fig. 2. *Landings of pink and brown shrimps at three ports in the Wash area. The failure of the pink shrimp fishery during* 1949 *and* 1950 *is reflected in the landings at Boston.*

1950, the decrease of landing at Boston was quite noticeable. This setback was also to be observed in the landings from the Thames area ports of Brightlingsea, West Mersea and Whitstable. At such ports as Harwich, Southend-on-Sea, Leigh-on-Sea and Queenborough, from which the shrimp boats fish both species,the decline during that period was not so marked (Fig. 3).

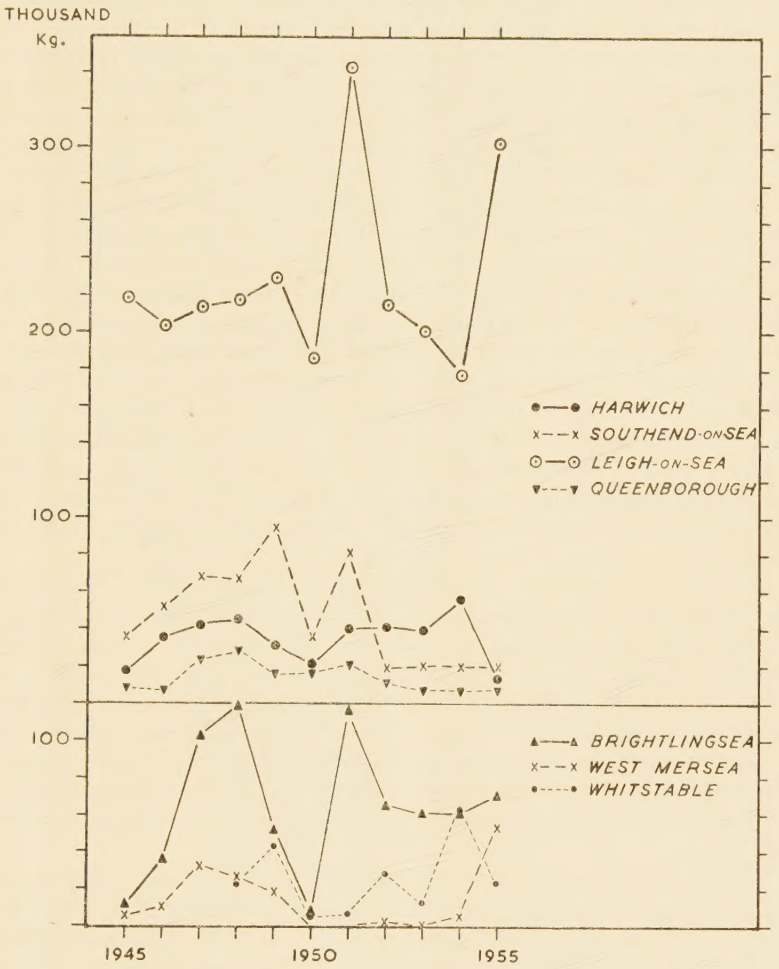

Fig. 3. *Landings of shrimps in the Thames area during a period of* 10 *years.*
Top: *Landings of brown and pink shrimps at four ports.* Below: *Landings at ports where mainly pink shrimps are landed.*

FISHING GEAR

On the east coast of England the beam trawl is used exclusively for fishing brown and pink shrimps. In the Thames area the otter-trawl has been introduced only recently, and there are only two boats employing it. On the north west coast in addition to the beam trawl, fishing of brown shrimps is done by push and shank nets, the latter being small trawls pulled by horse carts. In the Bristol Channel small quantities of brown and pink shrimps are taken in salmon putts and stall nets. However, approximately 90%, if not more, of the total landings are fished by the beam trawl.

The length of the beam varies between 18 and 24 feet, and to some degree this is related to the overall length of the shrimp boat. On the east coast the length most commonly used

is the 19 or 21 feet beam. In Morecambe and Liverpool Bays, where 'nobbies' of about 25 to 40 feet overall length are generally used, beams of 19 feet are employed. On commercial boats the total length of shrimp nets is usually one and a half times the length of the beam—in Essex between 27 and 36 feet.

The mesh-size of the nets varies from district to district, from port to port and even from boat to boat, as there are no statutory regulations issued by the central authority. The greater part of the coastline of England and Wales is divided up into eleven Sea Fisheries Districts and each District has its own Committee, with power to make bye-laws governing the mesh and size of nets not covered by statutory regulation. With the exception of the Kent and Essex and Cumberland Sea Fishery Committees and certain River Boards, there is no provision as to the minimum mesh-size for shrimp nets in England and Wales.

The Cumberland Committee requires all nets to have a mesh of such a size that a square piece of wood with a side of $\frac{3}{8}$ in. will pass through when the net is wet. Such a net has a mesh (internally, between the knots) of about 19 mm. Many Sea Fishery Committees limit to 25 feet the size of beam which may be used. The Kent and Essex Sea Fisheries Committee, whose authority covers the whole of the Thames area, has a bye-law regarding the mesh of shrimp, prawn and eel nets; "No person shall use in fishing for shrimps, prawns or eels any trawl net having more than 108 rows of knots to the linear yard, except that, for a length of 8 feet from the cod-end there may be not more than 144 rows of knots to the yard." Nets with 108 rows of knots to the yard, about 17 mm. full mesh and 144 rows to the yard, about 13 mm. in the cod-end, are considered to be too small. The fishermen in the Thames area have found from experience that a trawl net with a larger mesh avoids to some extent the capture of small shrimps and at the same time allows the release of small Gobiid fish (*Gobius minutus*), or 'white-throats' as they are commonly called, which can be a great nuisance when sorting a large catch of shrimps.

Indeed, the present mesh-size of shrimp trawls in use in the Thames area is often considerably larger than that specified in the above-mentioned bye-law. From information collected during 1949, the mesh among the shrimping fleet in this area varied between 72 and 94 rows to the linear yard, or approximately 19 to 25 mm. full mesh. A smaller mesh of 19 to 22 mm. is used for fishing pink shrimps, since the carapace of the pink shrimp is narrower than that of the brown shrimp. Since there are no regulations concerning the structure of shrimp trawls in this sea fishery district, the net may have a larger mesh in the cod-end than in the 'batings', or the reverse, but there is always a larger mesh in the 'wings' or 'gorings' than in the cod-end. In some instances the trawl may have a uniform mesh, except in the 'wings'.

The above-mentioned figures were not based on actual measurements, but on orders placed to factories supplying either complete trawls, or netting that is cut and joined by fishermen. In addition some fishermen make their own nets. No consideration was given to the fact that cotton twine shrinks when treated with various dressings, and that there is a further shrinkage when cotton and hemp twines are immersed in water (Klust, 1956). A total shrinkage of 10 to 15% would reduce the mesh by 2 or 3 mm.

METHODS

THREE shrimp trawls to fit a 12 foot beam were obtained in July, 1954. Although the most common beam is 19 or 21 foot long, it was considered that such large trawls could not easily be handled from the Station's boat. The nets were approximately 24 feet long, made from 16-ply reverse twist cotton throughout and treated with Green Cuprinol. The ground rope was leaded at intervals, but as it proved to be light and unprotected from chafing, two rows of $1\frac{1}{2}$ in. coir rope were wound along its whole length. The nets were corked after delivery, care being taken to ensure that all nets had the same number of corks and cork rows. Part of the 'belly' and the complete cod-end were protected by pieces of rubber inner motor tubes. The nets, when ordered, were to have a mesh of 16, 18 and 20 mm. in the

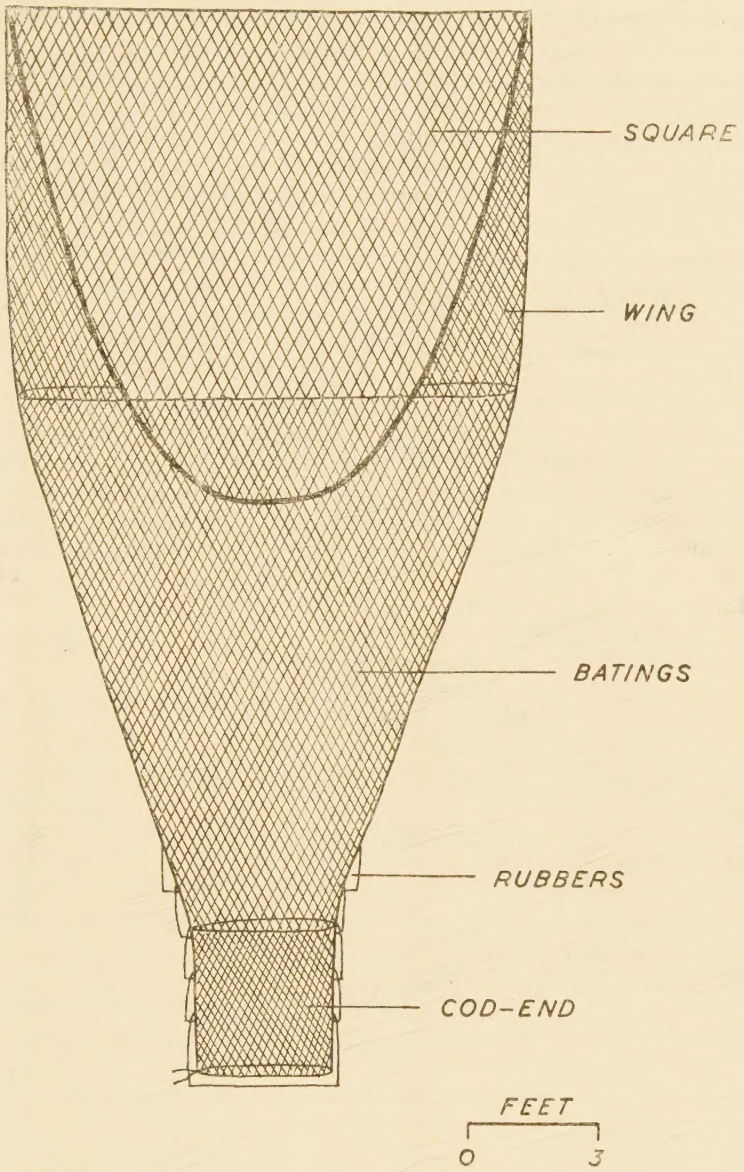

Fig. 4. *A diagram of a shrimp trawl net as used in the comparative fishing trials.*

cod-end, with an increase of 2 mm. in the 'batings' ('upper' and 'belly') and another 2 mm. in the 'square' and 'wings' (Fig. 4). On delivery the mesh, measured inside the knots, was smaller by approximately 0·8 to 1 mm. throughout.

Trawl hauls of 30, 50 and 60 minutes duration were made with these nets over pink shrimp grounds in the river Crouch, off Clacton-on-Sea and once off Harwich (Fig. 5). During trawling we aimed to cover the same distance over the ground, so that the hauls would be uniform. In the river Crouch, where visible marks exist on both banks, it was easier to judge the distance covered, than off Clacton-on-Sea, and, accordingly, the speed of towing could be regulated more easily. The distance covered in 30 or 60 minutes varied according to tides and time of tide. As shrimps are trawled with the ebb or flood tide, the towing speed increased a little at spring tides and a few hours after high water or low water. On the whole, the distance covered in 30 minutes towing varied between 1 and $1\frac{1}{4}$ miles and between 2 and $2\frac{1}{4}$ miles for 60 minutes towing.

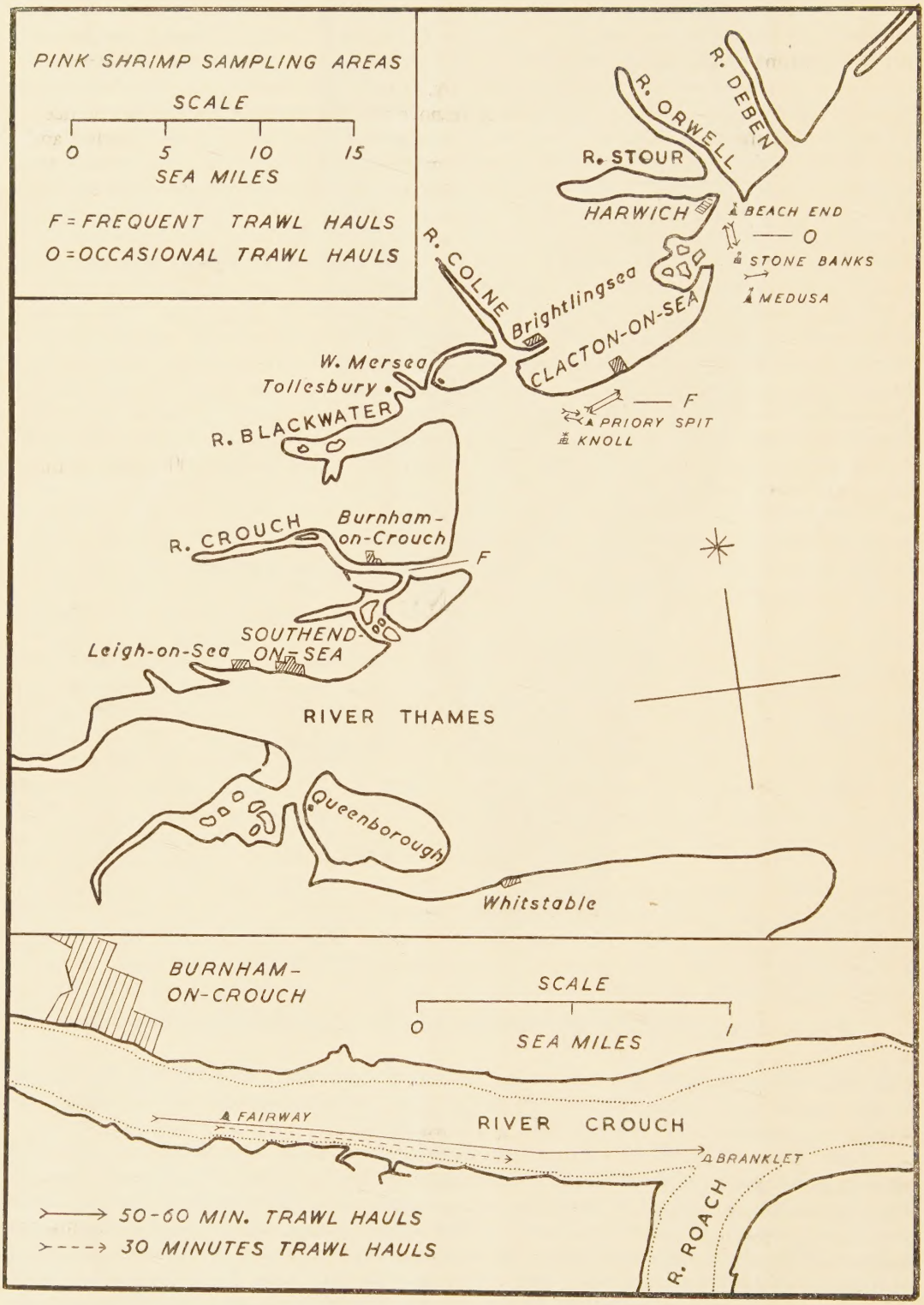

Fig. 5. *Map showing the Thames Estuary, and positions where trawl hauls for pink shrimps were made.*

The various mesh-size nets were used alternatively or in succession. Mesh-size was recorded frequently, by measuring not less than 30 meshes from each section of the net. At the beginning of the fishing trials the nets which had to be compared were fastened to two similar beams, these being used alternatively. It was soon found, however, that it was easier to remove and replace the net, than to remove the fully rigged trawl from the deck.

As soon as the trawl was emptied on deck the associated fauna was recorded and separated from the catch. A sample of shrimps, measured in a 2 pint vessel ($\frac{1}{4}$ gallon), was preserved in 4-5% formalin. The catch was measured and sieved through a 'threepenny' riddle; the quantity remaining on the sieve was also measured so as to calculate the percentage (by bulk) of riddled shrimps. As the name suggests, the distance between the wire bars in the riddle is the thickness of 3 pennies or approximately 5·2 mm. The riddle most commonly used in the Thames area is the 'threepenny' or the 'threepence halfpenny' (6·65 mm.); the 'fourpenny' (6·9 mm.) is used for brown shrimps. In other districts the 'twopenny' (3·4 mm.) or the 'twopence halfpenny' (4·9 mm.) riddles are used.

The preserved sample was counted to calculate the ratio of pink to brown shrimps in the catch and the complete sample, containing 300 to 700 pink shrimps, was measured. Measurements were based on the carapace length and an ordinary screw micrometer fitted with special jaws was used (Cole and Mistakidis, 1953). Shrimps were measured to 0·2 mm. and the data aggregated to 1·0 mm. groups. Altogether about 75,000 pink shrimps were measured.

COMPARATIVE FISHING TRIALS IN 1954

It will be of interest to summarise certain points of the life history of the pink shrimp (Mistakidis, 1957).

The pink shrimp fishery in the Thames area begins in April and continues until September or October. If the weather keeps moderate the shoals may remain longer over the grounds, but by November or December the shoals migrate to deeper water and do not re-appear in great numbers until April. In the Wash the fishery lasts longer, continuing until December or January. The breeding season is from November until May, with large scale larval liberations taking place in April. Growth is quite rapid during the first 6 or 7 months. Individuals of the 0-group, 4 to 9 mm. carapace length, appear in the catches during July or August and by November or December the female population attains a mean carapace length of $\pm$ 11·0 mm. and the male $\pm$ 10·0 mm. During the next two years growth is retarded, the annual carapace length increment being only 2 to 3 mm., but some individuals attain carapace lengths of 16 to 19 mm., by the end of their life span. In Crustacea age cannot be judged by size alone, and, since pink shrimps exhibit sex reversal, the distinction between 1- and 2-year groups is very difficult. Individuals of 17 to 19 mm. carapace length may be 4 years old. The total length of pink shrimps, from the tip of the antennular scale to the tip of the telson, can be found by multiplying carapace length by 4·5 (Mistakidis, 1957).

Female shrimps of a carapace length of less than 11 mm. in November, and males less than 10 mm., were considered to be immature. Any shrimps of less than 10·6 mm. carapace length (48·0 mm. total length), were considered as undersized from a marketable standpoint and the dividing line between commercial and non-commercial shrimps was drawn at this figure, which is what commercial operators would consider suitable.

Owing to the late delivery of nets, fishing trials did not begin until the middle of August. In September the Station's boat was not available, and trials were suspended until the following year. The results obtained during August 1954 showed that high percentages of small pink shrimps were retained by nets with a mesh of 13·0 to 18·0 mm. in the cod-end (Table I). The lowest percentages of non-commercial pink shrimps were observed on 11 August, 56 to 65%, and the highest, 82 to 94%, later in the month. It was apparent that more juvenile individuals had entered the catches, with a corresponding reduction in the

proportion of older individuals. In all cases the smallest mesh-size net was yielding larger total catches. Riddling did not show a reduction similar to the percentage of non-commercial shrimps in the catches. As the catches contained such high percentages of small individuals the riddle became blocked and did not allow their passage through the wires. Further, riddling became less efficient with the presence of various shells, *Cardium*, *Mytilus*, *Crepidula*, and bryozoans, *Flustra* and *Alcyonidium gelatinosum*, which could not be sorted properly beforehand. The shrimps are sieved by shaking the riddle and the more vigorous the shaking, the more efficient it becomes.

Table I: *Results obtained from comparative fishing trials in August* 1954

Date	*Fishing Ground*	*Net*	*Cod-end mesh (mm.)*	*No. of Hauls*	*Duration (min.)*	*Unriddled catch (gallons*)*	*Riddled catch (gallons)*	*Loss through riddling (% Vol.)*	*Non-commercial (% No.)*
11.8	R. Crouch	I	14·0	2	30	5·00	3·25	35·0	65·7
		III	18·0	2	30	1·37	0·75	45·2	56·6
19.8	R. Crouch	I	13·0	2	30	5·62	1·96	65·1	83·0
		II	16·0	2	30	3·13	1·13	63·9	81·9
20.8	Clacton	I	13·0	2	30	6·50	2·13	67·2	92·4
		III	17·0	2	30	3·75	1·00	73·3	93·3
23.8	Clacton	I	13·0	2	30	4·75	1·19	74·9	94·5
		II	15·5	2	30	3·06	0·94	69·2	87·1

*Catches do not include sample of 1/4 gallon per haul.

At the end of the fishing trials all the nets had shrunk by 1·5 to 2 mm., or a reduction of 8 to 13% in the mesh. Such shrinkage had brought the smallest mesh-size net, (net No. I), to 13·0 mm. in the cod-end, and the largest (net No. III) to 17·0 mm. It was obvious that net No. I could not be used again and, as the existing mesh range was smaller than that of the commercial nets, two new nets with a mesh of 22·0 and 24·0 mm. in the cod-end were ordered for further comparative trials.

COMPARATIVE FISHING TRIALS IN 1955

THE two new nets were delivered at the end of April and fishing trials were started at the end of May. On delivery one net had a mesh 0·7 to 1 mm. smaller than required and the other was totally inadequate and had to be returned to the makers, with the result that it could not be used until mid July.

The results obtained from 20 half-hour hauls on grounds in the river Crouch and off Harwich, Stone Bank and Medusa Buoys (Fig. 5), between 26 May and 16 June 1955, showed that catches of non-commercial shrimps were small, not exceeding 15%. Although in some cases the difference in mesh between the nets compared was 4·0 to 5·5 mm., the rates of retention of small shrimps did not vary significantly (Table II). As in the previous year, nets with a smaller mesh, except in one case, were yielding higher catches than the nets with the largest mesh. The percentage loss through riddling was now higher than the percentage of non-commercial shrimps present in the catches. As the percentages of small shrimps were low, some of those of more than 10·6 mm. carapace length must have passed through the riddle.

When the 0-group pink shrimps entered the catches during July, the net with the smallest mesh retained more non-commercial shrimps than the larger mesh-size. The rates of retention increased gradually until they reached the high figures of 89 to 93% by the middle of September, but decreased to 50 to 60% by the end of November. At that season, many shrimps of the 0-group had a carapace length greater than 10·0 mm. (Fig. 6).

Table II: *Results obtained from comparative fishing trials in* 1955

Date	*Fishing Ground*	*Net*	*Cod-end mesh (mm.)*	*No. of Hauls*	*Duration (min.)*	*Unriddled catch (gallons*)*	*Riddled catch (gallons)*	*Loss through riddling (% Vol.)*	*Non-commercial (% No.)*
26.5	R. Crouch	III	16·0	2	30	5·50	3·25	40·9	11·3
		IV	20·5	2	30	4·25	2·75	35·3	7·0
3.6	R. Crouch	II	14·5	2	30	8·00	5·18	35·2	6·3
		IV	20·0	2	30	7·00	5·12	26·8	4·3
14.6	Stone Banks	III	15·0	2	30	2·87	2·12	26·1	13·6
		IV	19·0	2	30	1·75	1·00	42·8	14·9
15.6	Stone Banks	III	15·0	2	30	2·12	1·43	32·5	11·4
		IV	19·0	2	30	1·12	0·87	22·3	14·2
16.6	Medusa	II	14·0	2	30	3·25	2·37	27·0	12·0
		IV	18·5	2	30	6·87	4·87	29·1	11·6
14.7	R. Crouch	II	14·5	2	30	0·50	0·21	58·0	32·8
		IV	18·5	2	30	1·62	1·28	20·9	7·4
15.7	Clacton	IV	18·5	2	30	2·50	1·68	32·8	14·0
		V	22·5	2	30	1·25	0·81	35·2	13·9
4.8	Clacton	IV	18·5	2	30	4·37	2·37	45·7	36·6
		V	21·0	2	30	2·18	1·31	39·9	20·1
11.8	R. Crouch	III	14·5	2	30	1·62	0·62	61·7	77·3
		V	20·5	2	30	0·44	0·25	43·2	43·1
15.8	Clacton	III	14·5	2	30	4·81	2·50	48·0	59·1
		V	20·5	2	30	6·69	4·19	37·3	40·0
15.9	R. Crouch	IV	19·0	1	30	2·87	0·69	75·9	92·5
		V	21·0	2	30	3·63	1·13	68·8	89·3
11.10	R. Crouch	IV	19·0	2	30	3·87	2·25	41·8	76·7
		V	21·0	2	30	1·75	0·56	68·0	65·1
27.10	Clacton	IV	19·0	2	30	8·00	4·62	42·2	45·5
		V	21·0	2	30	4·75	3·12	34·3	45·2
9.11	R. Crouch	III	14·5	2	30	0·81	0·38	53·1	71·5
		V	20·5	2	30	1·50	0·69	54·0	58·2
25.11	R. Crouch	III	15·0	2	30	2·25	0·87	61·3	61·1
		V	21·0	2	30	1·50	0·63	58·0	51·4
28.11	Clacton	III	15·0	2	30	2·50	1·00	60·0	48·3
		V	21·0	2	30	4·00	2·25	43·7	50·5

*Catches do not include sample of 1/4 gallon per haul.

The percentage loss through riddling, during August and September, was smaller than the percentage of non-commercial shrimps present in the catches. From October to the end of November, the losses were more or less similar to the percentages of small shrimps retained by the various nets. During the period July to November, when 43 half-hour hauls were made in the river Crouch and off Clacton-on-Sea, the smaller mesh-size nets retained higher percentages of non-commercial shrimps than the nets with a larger mesh. In one case the results were reversed but the difference in retention was only 2%. Nets with a smaller mesh did not always yield larger total catches as they had in the previous year. Out of 10 comparative trials, 4 showed larger total catches with a larger mesh, and 6 larger catches with a smaller mesh. During this period catches of pink shrimps were generally small over the whole Thames area, and it is possible that this scarcity was reflected in the fishing of the nets.

Shrinkage of nets was again observed during 1955. Nets obtained in 1954 shrank by another 2mm., resulting in a total shrinkage of 17 to 21%. This shrinkage was observed at the beginning of the season, the mesh remaining more or less constant afterwards. Nets obtained during 1955 shrank by 9%, reducing the original meshes of 21·0 and 23·0 mm. in the cod-end to 19·0 and 21·0 mm. respectively.

During 1954, when only a small number of observations was made, the nets compared retained as high as 94·5% of non-commercial shrimps. Similar high rates of retention were

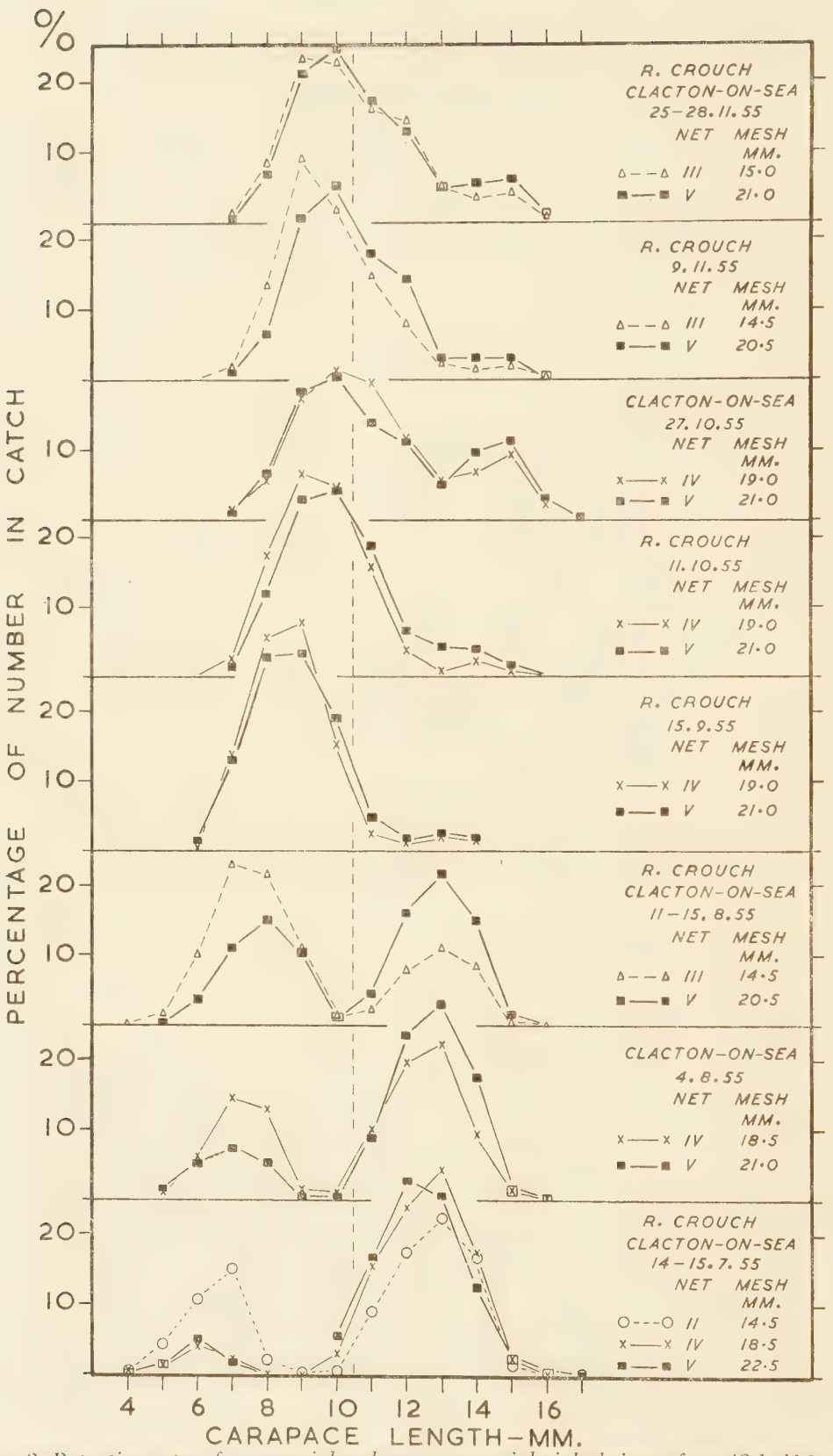

Fig. 6. *Retention rates of commercial and non-commercial pink shrimps, from 43 half-hour hauls made from July to November 1955.*

Shrimps below 10·6 mm. carapace length are considered to have no commercial value.

observed also in 1955, but only in the middle of September. As these high figures were obtained from nets with 19·0 and 21·0 mm. mesh in the cod-end, it was considered necessary to continue the trials by comparing nets with still larger mesh. Hjort and Ruud (1938) and Regan *et. al.* (1957)†, have also observed that nets with a small mesh may retain up to 90 and 98% of small prawns or shrimps.

COMPARATIVE FISHING TRIALS IN 1956

Table III: *Results obtained from comparative fishing trials in* 1956

Date	*Fishing Ground*	*Net*	*Cod-end mesh (mm.)*	*No. of Hauls*	*Duration (min.)*	*Unriddled catch (gallons*)*	*Riddled catch (gallons)*	*Loss through riddling (% Vol.)*	*Non-commercial (% No.)*
4.5	R. Crouch	V	21·0	2	30	2·75	1·25	54·5	48·6
		VII	23·0	2	30	2·31	0·81	64·9	41·3
8.5	Clacton	V	21·0	2	30	3·31	1·38	58·3	49·7
		VII	23·0	2	30	2·38	0·94	60·5	44·4
17.5	Clacton	IV	19·0	2	30	2·94	1·31	55·4	38·0
		VI	21·5	2	30	1·88	0·88	53·2	34·3
18.5	R. Crouch	IV	19·0	2	30	1·25	0·56	55·2	33·6
		VI	21·5	2	30	2·38	1·06	55·4	27·2
1.6	R. Crouch	IV	18·5	2	60	2·88	1·38	52·1	13·7
		VII	22·5	2	60	3·81	2·38	37·5	11·6
4.6	R. Crouch	IV	18·5	2	55	11·25	7·25	35·5	17·0
		VI	21·5	2	55	7·00	4·44	36·6	10·2
5.6	R. Crouch	IV	18·5	2	50	5·50	3·25	40·9	16·9
		VII	23·0	2	55	3·00	1·70	43·3	11·5
15.6	Clacton	III	15·5	2	60	12·00	8·44	33·3	10·8
		VII	23·0	2	60	8·00	6·56	18·0	11·6
18.6	Clacton	III	15·5	2	60	7·00	4·00	42·8	13·1
		VII	23·0	2	60	6·06	4·25	29·9	14·8
3.7	Clacton	III	12·5	1	60	2·75	1·50	45·4	7·5
		VI	20·0	1	60	1·88	1·12	40·4	4·9
12.7	R. Crouch	III	12·5	1	60	6·75	4·50	33·3	24·7
		VI	20·0	1	60	9·25	6·50	29·7	13·6
13.7	R. Crouch	VI	20·0	2	60	6·75	4·81	28·7	12·3
31.7	R. Crouch	V	18·0	2	60	14·88	10·25	31·1	17·6
		VIII	26·0	2	60	1·75	1·31	25·1	0·8
13.8	R. Crouch	V	18·0	2	45	11·50	6·00	47·8	57·4
		VIII	25·0	2	45	1·38	1·13	18·1	12·7
15.8	R. Crouch	IV	16·0	4	50	23·37	13·19	43·6	65·7
		VIII	25·0	4	50	5·12	3·81	25·6	13·9
16.8	R. Crouch	VI	20·0	4	50	15·50	8·31	46·4	58·9
		VIII	24·0	4	50	1·94	1·31	32·5	22·7
17.8	R. Crouch	VII	21·0	4	50	23·12	11·31	51·1	52·9
		VIII	24·0	4	50	5·56	4·09	26·4	26·2
28.8	R. Crouch	VII	21·0	4	50	25·18	9·75	61·3	67·7
		VIII	24·0	4	50	2·68	1·64	38·8	51·5
29.8	R. Crouch	VI	20·0	4	50	18·50	7·94	57·1	74·4
		VIII	24·0	4	50	4·62	2·50	45·9	55·2
30.8	R. Crouch	IV	16·0	4	50	14·00	4·50	67·8	81·9
		VIII	24·0	4	50	2·68	1·25	53·4	68·0
3.9	R. Crouch	V	18·0	4	50	18·50	8·19	55·7	83·3
		VIII	24·0	4	50	5·31	2·62	50·7	44·6

* Catch does not include sample of 1/4 gallon per haul.

† Previous notes on this work have been published in the *Commercial Fisheries Review*, Washington, Vol. **18**, No. 8, p. 26, 1956.

Early in 1956 two nets of 26·0 and 28·0 mm. mesh in the cod-end were obtained. As in previous years the mesh was found, on delivery, to be smaller than ordered, by 0·5 to 1·0 mm. After the first few trials it was observed that the nets shrank by 14 and 16% respectively and it was decided to order another net with a mesh of 30·0 mm. in the cod-end. This net was not delivered until the end of July and it was found instead to have a mesh of 28·0 mm.

The results obtained during May and June 1956 (Table III) were not unlike those observed during May and June 1955 (Table II). However, as the trials started earlier in 1956, the population contained more individuals of smaller carapace length and the rates of retention of undersized shrimps were higher. By June the population was more or less the same as found in June 1955, and the rates of retention became similar (Tables II and III). It was again noticed that at this season of the year the variation in rates of retention of non-commercial shrimps was not very marked, although the differences in mesh of the nets compared were 2 to 7 mm. During this period, when 36 hauls of half- or one-hour duration were made, with the exception of two trials, the smaller mesh-size nets yielded bigger total catches (Table III). The percentage losses through riddling were again higher than the percentages of small shrimps in the catches, and it was evident that some individuals of 11·0 mm. carapace length passed through the 'threepenny' riddle.

At the end of June 1956, Nets III, IV, V and VII were showing signs of wear and were treated with Green Cuprinol. When these nets were again used during July and August, measurements of the mesh were taken and a further shrinkage was observed. The greatest shrinkage was in Net III, and as the final mesh of 12·5 mm. in the cod-end was considered too small for further comparative trials, it was not again employed.

Net	*Prior to treatment* *Cod-end mesh* (mm.)	*After treatment* *Cod-end mesh* (mm.)	*Shrinkage* (%)
III	15·5	12·5	19·3
IV	18·5	16·0	13·5
V	21·0	18·0	14·3
VII	23·0	21·0	8·7

Pink shrimps of the 0-group, appearing in the catches in very small numbers at the beginning of July, became more numerous by the middle of the month. Even so, they were not as numerous as in July 1955, and in addition they were of smaller carapace length. It is possible that liberation of larvae was later in 1956, due to lower temperatures experienced early in the year. By mid August 1956 the composition of the catches was quite similar to that of August 1955.

During the summer of 1956, pink shrimps were more abundant than in 1955, and catches were large enough for effective comparison. From 13 August to 3 September, 60 hauls, each of forty-five or fifty minutes duration, were made over the same ground in the river Crouch, comparing the net with the largest mesh (VIII) with four others of smaller mesh. Net VIII, which on delivery had a mesh of 28·0 mm. in the cod-end, showed a shrinkage of 7% after the first trial, and a further shrinkage of 8% after several trials, becoming 24·0 mm. by mid August. This mesh was constant until the end of the fishing trials. Throughout this period Net VIII was yielding consistently smaller total catches than the other nets with smaller mesh (Table III and Fig. 7). The retention of non-commercial shrimps was also less, the difference being 27 to 52% in the first fortnight of August and becoming 12 to 39% in the second fortnight, when large numbers of small shrimps entered the catches. The increase of small shrimps was also reflected in the catches of the smaller mesh-size nets. From 13 to 17 August, for nets with a mesh of 16·0 to 21·0 mm. in the cod-end, rates of retention were 53 to 66%, while from 28 August to 3 September they were 68 to 83%. These results confirmed the previous observation that, during August and September, nets with a mesh of 16·0 to 21·0 mm. in the cod-end retain from 55 to 85% of non-commercial shrimps. The net with a mesh of 24·0 mm. in the cod-end also retained

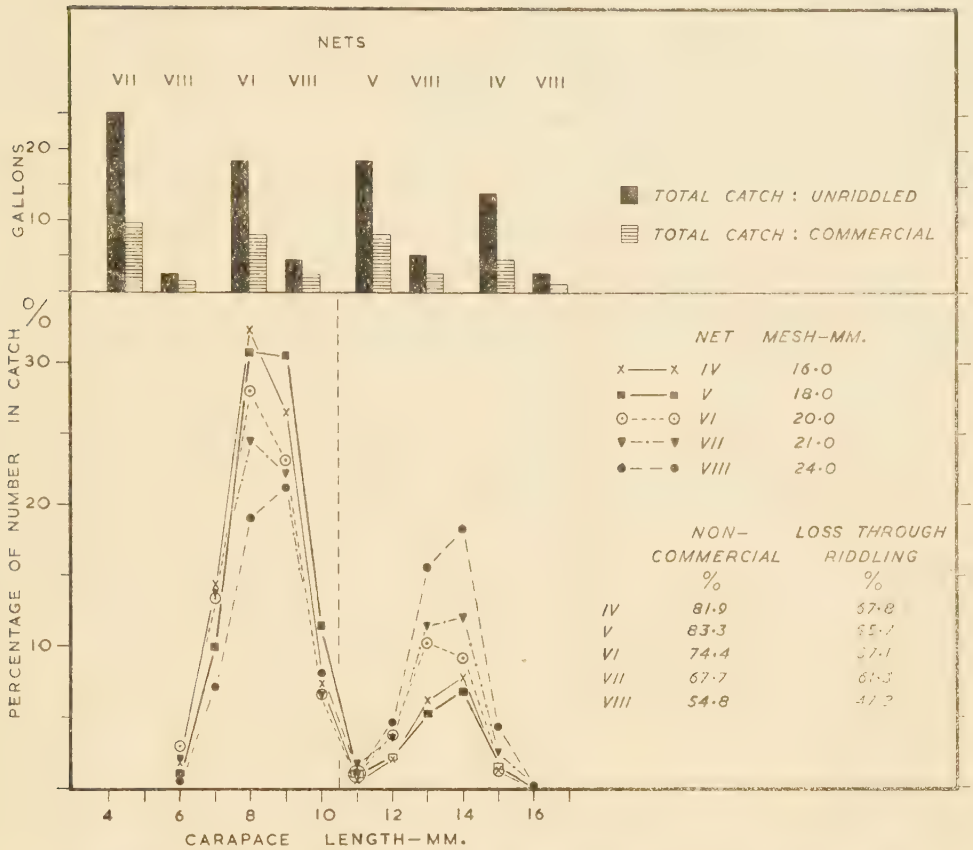

Fig. 7. *Retention rates of commercial and non-commercial pink shrimps, from 32 fifty-minute hauls made from 28 August to 3 September 1956, in the river Crouch.*
Top: *Total catches of pink shrimps, before and after riddling (excluding ¼ gallon sample per haul), obtained from five nets with various mesh-sizes.*

55% of small shrimps, but the total catches were considerably less than from those of smaller mesh-size nets. It is considered, therefore, that the net most suitable for pink shrimps is one with a mesh of between 22·0 and 23·0 mm. in the cod-end.

The aim of the comparative fishing trials was to discover which mesh would release the largest quantities of non-commercial pink shrimps, without noticeably reducing the total catches. If the proportion of brown shrimps in the catches had been substantial, this would have affected the calculations, since brown shrimps have a broader carapace than pink shrimps. However, the analysis of 185 samples collected during 1954-56 showed that the percentage of pink shrimps varied between 70 and 100%, with the majority more than 85%, while the mean percentage of all observations varied in these three years between 88 and 98%.

Mean % of pink shrimps in the catches.

Year	*R. Crouch*	*Clacton-on-Sea*
1954	90·54	89·58
1955	92·29	89·84
1956	88·73	98·31

In observations made from 1950 to 1952, excluding those made during the winter months, the percentage of pink shrimps from samples off Clacton-on-Sea was 87·74, while

the river Crouch percentage was smaller, 76·41, but the ground fished then was nearer the river mouth than that used for the comparative fishing trials described above, with bottom conditions more suitable for brown shrimps.

SURVIVAL RATES OF PINK AND BROWN SHRIMPS

It has been mentioned earlier that pink shrimps succumb more quickly than brown shrimps when taken out of the water. During the summer months of 1956, a series of observations showed that when pink shrimps remained on deck for over 20 minutes, the rates of survival were very low.

A number of pink shrimps, at least 50, were taken at random from the catch and were thrown into an enamel bath after a specified period. When brown shrimps were present in the catch, a small number was taken as well. The air temperature, seawater temperature and the temperature of the water in the bath, together with the time elapsing between hauling the net on deck and re-immersing the shrimps, were noted. After a fixed period of time the shrimps swimming actively were counted, and removed from the bath.

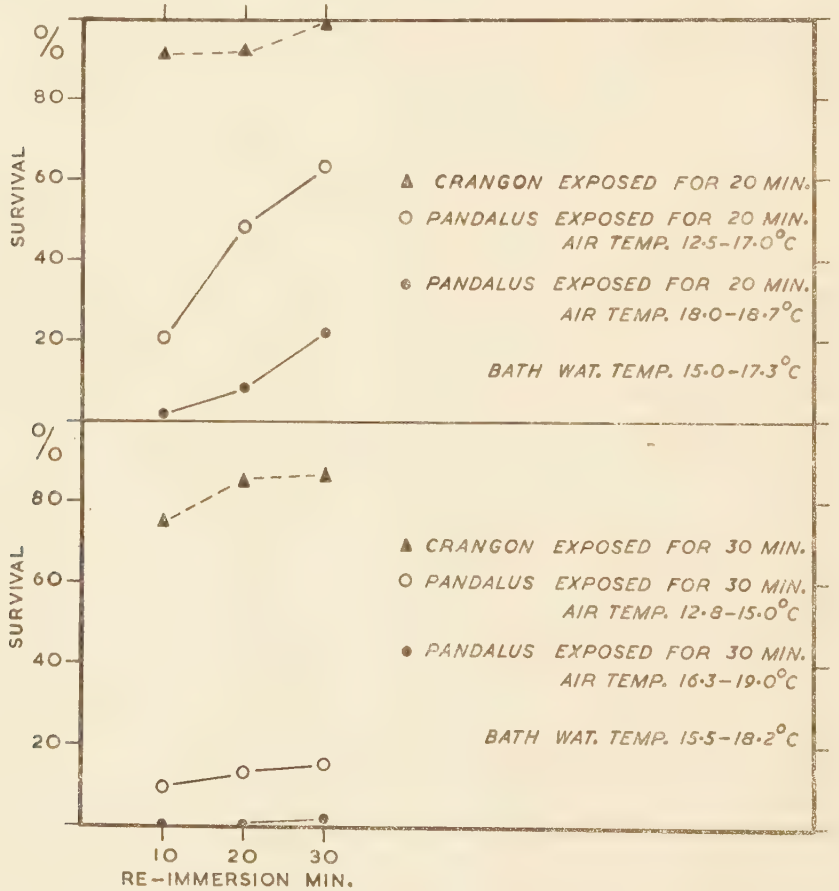

Fig. 8. *Survival rates of pink and brown shrimps after re-immersion in seawater.*

Top: *Mean survival rates from* 14 *observations in which pink and brown shrimps were exposed for* 20 *minutes at different air temperatures.* Below: *Mean survival rates from* 10 *observations in which pink and brown shrimps were exposed for* 30 *minutes at different air temperatures. In both series of observations brown shrimps did not show any marked differences in survival as a result of varying air temperatures.*

The percentage survival depended on the length of exposure to air. When pink shrimps were re-immersed after 2-4 minutes exposure, the percentage survival was 72 to 95%, after 10-15 minutes, 10 to 48% and after 20-23 minutes, 0 to 10%. In the case of brown shrimps, the survival rate was between 80 and 100%. Although the air temperature varied between 10 and 17°C. and the water temperature in the bath between 12 and 16°C., the differences in survival rates were not very marked. Admittedly they were lower with higher air and water temperatures, but they also varied according to whether it was blue sky or overcast, or whether it was calm or windy.

In the above series of observations the shrimps were left in the bath for only 5 minutes. It was found, however, that if the re-immersed shrimps were left for a longer period in the bath, the percentage survival increased. In 9 trials, in which pink shrimps were re-immersed after 20 minutes exposure, the survival rate increased from 20 to 48% when the period of re-immersion was increased from 10 to 20 minutes. When they were left for a further 10 minutes, the survival rate increased to 63%. In this case the air temperature varied between 12·5 and 17·0°C. When the air temperature varied between 18·0 and 18·7°C. the mean of 5 observations was considerably lower (Fig. 8). The survival rate of brown shrimps, from a similar number of observations, showed that the increase was only 9%, i.e. 91 to 99% when shrimps were left re-immersed for periods of 10, 20 and 30 minutes duration.

In another series of observations pink and brown shrimps were exposed for a period of 30 minutes before re-immersion. When air temperatures varied between 12·8 and 15·0°C., the survival rate of pink shrimps was not higher than 15%, even if they were left for 30 minutes in the bath. With air temperatures of 16·3 to 19·0°C., the survival rate was between nil and 1·5% (Fig. 8). The survival of brown shrimps for the same period of exposure and re-immersion was between 75 and 86%.

DISCUSSION

The comparative fishing trials conducted during 1954, 1955 and 1956 confirmed previous observations (Hjort and Ruud, 1938; Roelofs, 1950; Gilis, 1952b) that percentages of non-commercial shrimps in the catches become lower when a larger mesh is introduced. Nets with larger mesh, however, still retain immature shrimps, and it is apparent that not all small shrimps can escape through the mesh. With more shrimps entering the net, the previously captured shrimps are being pushed further towards the main catch. In addition the majority of catches contain a variety of invertebrates and vertebrates which tend to block the mesh.

In the present series of observations, the associated fauna occurring in the catches was noted. Out of a total of 185 hauls, 93 different species of Algae, invertebrates and fishes were recorded (Appendices I, II and III). Although some of the species recorded occurred quite frequently, it is considered that only some of them have a blocking effect. Among the invertebrates, the most likely species to block the mesh are the two species of crab, *Portunus* sp. and *Carcinus maenas*, the bryozoans, *Alcyonidium gelatinosum* and *Flustra foliacea* ('gelatinous weed' and 'lemon weed'), the echinoderms, *Solaster papposus* and *Asterias rubens* ('rose' and 'starfish') and shell of *Cardium edule*, *Crepidula fornicata* and *Mytilus edulis*. The density of mollusc shells may vary from ground to ground or area to area. In the present trials *Cardium* and *Crepidula* shells were mostly present on the river Crouch ground. Six species of fish, *Agonus cataphractus*, *Gobius minutus*, *Solea vulgaris*, *Clupea sprattus*, *Gadus luscus* and *Gadus merlangus* were present in one third of the hauls made, and in certain hauls they were quite numerous. The Ctenophore *Pleurobrachia pileus* ('sea-gooseberry') was also frequent in the catches, being extremely abundant at certain times of the year. Various Algae may also block the mesh. The presence of such a variety of organisms in the catches may explain the anomaly of occasionally observing very small differences in the rates of retention of small shrimps, although the difference in mesh was 4 or 6 mm.

As it has been mentioned earlier, the official landings do not differentiate between pink and brown shrimps, and, therefore, no conclusive opinion can be reached regarding the decline in one particular fishery. Although there is a downward trend in landings since 1920, this may be the result of reduced fishing effort. The mean annual catches for three periods of 10 years, 1920-29, 1930-39, 1946-55, were 49,080, 43,980 and 38,640 cwt. respectively, showing a decrease of approximately 5,000 cwt. for every 10 years. The mean annual catch for the period 1910-19, including the years of World War I, was 54,390 cwt., while the corresponding figure for the period 1940-45 was only 29,360 cwt.

Conflicting opinions exist with regard to overfishing of the shrimp stock. Havinga (1951a), studying the landings of brown shrimps in Holland, stated that the natural mortality is very great compared to mortality caused by fishing, with millions of shrimps taken as food by various species of fish, and accordingly no protective measures had been devised. In a later publication (Havinga, 1951b), he pointed out that statistics of catches per unit effort are of considerable value, if differences in landings are the result of natural mortality or from the effect of the fishery. Havinga (1956) stated that catches per unit effort have decreased since the war along the whole Dutch coast, but this decrease of stock may not be solely due to overfishing. Changes in hydrographical conditions or increase in the number of predators could be possible factors. Gilis (1952b) pointed out the decrease of brown shrimp landings on the Belgian coast and assumed it to be due to fishing and destruction of immature shrimps. He considered also the reduction of boats engaged in the fishery, and the factors of unfavourable hydrographical conditions and predators, particularly that of *Gadus merlangus*. Gilis recommended the introduction of a larger mesh (an increase from 16·0 or 18·0 mm. to 24·0 mm. in the cod-end) and suggested an international agreement between Holland, Belgium and France with regard to a mesh size for shrimp trawls.

Fujinaga (1955), discussing the question of conservation of the prawn *Penaeus japonicus*, concluded that the stock is almost entirely dependent upon changes of the physical environment, the intensity of fishing having hardly any effect upon the condition of the resources. In Australia, the work of Racek (Harris, 1956), revealed that only a small portion of the main stock of prawns in ocean waters comes into the estuaries and lagoons. Since the estuarine stock remains constant, Harris believed that there should be no objection to the removal of the minimum legal-size protection of prawns.

The effect and influence of environmental conditions on shrimp or prawn fisheries in widely separated areas cannot be disputed. Severe winters may reduce the spawning individuals, or destroy to a large extent the larvae, and pollution of the sea-water may affect the food. In addition, the increase in numbers of predators may influence the stock. There is no statistical information regarding an increase of predators on the pink shrimp grounds of the Thames area. During 1950, when pink shrimps were scarce, two Gadoid species (whiting, *Gadus merlangus*; whiting pout, *Gadus luscus*) were more abundant than in previous years and fishermen correlated the decrease of catches with increase of predators. The examination of 180 stomachs of whiting and 140 stomachs of whiting pout, during 1950-51, showed that in addition to various fish remains, mysids, polychaetes and crustaceans, the mean numbers of shrimps found in the stomachs of whiting and whiting pout were 1·4 and 1·2 respectively. Of the shrimps taken, 70 to 75% were pink shrimps. Gilis's figures for brown shrimps taken by the same two species were 2·1 and 2·5 respectively. Gilis (1952b) found, however, a mean figure of 8·5 and 12·5 in 46 stomachs of rays and 12 stomachs of gurnards (*Trigla corax*), with 17 brown shrimps in a single cod.

Linder (1955) stated that each species and each stock of species of shrimps must be treated as a separate unit when its management is being considered. The pink shrimp cannot be compared to the brown shrimp, which has two spawning seasons and which lays almost twice the number of eggs, or with *Penaeus japonicus*, where a single large female lays 700,000 eggs. According to Linder, before regulations are formulated, a concise idea of the shrimp stock in respect of population dynamics is needed. In England and Wales the stock of pink shrimps is not known, and in addition there are no available figures of the exact landings. The question is, whether the large quantities of small pink shrimps

destroyed every year during August to October are replenished in the following year by the remaining individuals of the 0-group. If the catch is greater than the equilibrium catch, the population will decrease and regulation should be enforced. If the fishery is not affected by this destruction, no regulations are necessary. If, however, a large number of future spawners are taken out from the population and successive adverse environmental conditions prevail during and after hatching, the stock will decrease during the following years, and the fishery will not revive until favourable conditions re-occur.

Review of trials shows that often even a substantial difference of mesh did not give a substantial alteration in the run of sizes in the catch, especially after the new young shrimps came into the catches.

Sometimes, as in July and August 1955, there is a noticeable saving effect and corresponding losses of good shrimps, as judged by the riddled catch, are not inevitable. The practice of fishermen in the Thames Estuary, who, as already stated, use a larger than legal mesh, suggests that results like those of July and August 1955, are possibly of greater practical importance than is shown by our sampling, and enlargement to 22 or 23 mm. may well be beneficial.

Enlarging the mesh as high as 24 mm. is almost certainly ruled out by the invariable and severe reduction in riddled catches shown in Table III and Fig. 7. Even mesh of from 20 to 23 mm. showed loss of riddled catch as often as not (Table III), and since there is no reason for believing that a large proportion of those saved will be caught later, there is no scientific basis for recommending a mesh regulation. If, however, practical opinion is strongly in favour of such a regulation, it would seem that 23 mm. (internal, clear of knots) would be a good mesh to use, on the grounds of sexual maturity and attainment of adult size of the pink shrimp.

Turning to the practice of riddling, return to the sea is evidently of small value for the pink shrimp if the undersized shrimps are not put overboard in less than 30 minutes. However, riddling is likely to be fully effective for the saving of small brown shrimps.

During August to October unriddled catches of 30 to 50 gallons taken with the present mesh-size nets may contain 75,000 to 125,000 individuals of pink shrimps. The average number of shrimps per gallon from 30 samples obtained during August 1956, with nets of 16·0 to 21·0 mm. mesh, was 2,446. Assuming that during this period the nets retain 60 to 80% of non-commercial shrimps, about 45,000 to 100,000 individuals will be lost per boat, per day, if the catch is not riddled soon after hauling.

Measurements taken in 1957 from certain boats at Harwich, Brightlingsea, Tollesbury, Leigh-on-Sea and Whitstable, showed that commercial shrimp nets have a mesh of 18·0 to 21·5 mm. in the cod-end, with a larger mesh in the 'wings' or 'gorings'. It was observed, however, that the 'batings' of some trawls often had a smaller mesh than the cod-end, being in the region of 17·0 to 21·0 mm. The most suitable mesh for pink shrimps in the Thames area would be of 22·0 to 23·0 mm., measured wet and inside the knots, and the adoption of this net would not represent a great increase such as might be resented by the fishermen. What is desired, also, is an increase of 2·0 to 3·0 mm. of the mesh in the 'batings', since, being the largest part of the trawl, the small shrimps will escape through this portion rather than through the cod-end. A uniform mesh of 22·0 to 23·0 mm. throughout the 'batings' and cod-end would be most effective.

As all the nets, which were of 16-ply reverse twist cotton, showed shrinkages of 15 to 23% at the end of the trials, and various twines are known to show different degrees of shrinkage after 24 hours immersion in salt water (Klust, 1956), this subject should be fully considered when mesh-size regulations are being formulated.

SUMMARY

1. During the summer months large numbers of non-commercial pink shrimps (below 10·6 mm. carapace length), are taken with the present mesh-size trawl nets. Although

the shrimps are eventually returned to the sea, a large proportion will perish if the period between hauling and riddling the catch is more than 20 minutes.

2. In England and Wales, except in two Sea Fishery Districts, there is no provision as to the minimum mesh-size of nets used for taking shrimps. The mesh of the commercial shrimp nets used in the Thames area varies from 17 to 21 mm. in the cod-end. It was considered that the introduction of a larger mesh would limit the destruction of non-commercial shrimps, and at the same time would reduce the labour and time taken in riddling the catch.
3. During the summer of 1954, and spring and summer months of 1955 and 1956, a series of trawl hauls was made with various mesh-size nets. The range of mesh in the cod-end of the nets employed was from 13 to 24 mm. Results obtained from 185 half- or one-hour trawl hauls made on grounds in the river Crouch and off Clacton-on-Sea, showed that the proportion of non-commercial shrimps retained by the nets varied according to season, being 10 to 50% between May and July, and 50 to 90% between August and November, soon after the 0-group shrimps entered the catches.
4. Generally, nets with a small mesh retained higher percentages of non-commercial shrimps, and also yielded larger saleable catches than nets with a larger mesh. Although the net with the largest mesh (24 mm. in the cod-end) retained smaller percentages of non-commercial shrimps, it yielded consistently smaller total catches even after riddling. Satisfactory catches of commercial-size shrimps were obtained with nets having meshes of 21 and 23 mm. in the cod-end. These nets still retained a large proportion of small shrimps, but less than that taken by nets with meshes of 16 to 18 mm. If a mesh regulation is required, it is considered that the net most suitable for pink shrimp trawling is one with a mesh of between 22 and 23 mm. in the cod-end; no netting of smaller mesh should be used in the 'batings' or 'body' of the net.
5. All the nets employed in the present series of observations, which were of 16-ply reverse twist cotton, showed shrinkage of 15 to 23% by the end of the trials.
6. Observations on survival showed that when pink shrimps were exposed for 30 minutes, the survival rates varied between 1·5 and 15%. The survival rates for brown shrimps, for the same period of exposure, varied between 75 and 86%.

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APPENDICES

APPENDIX I

List of Invertebrata except Mollusca, with their frequencies, observed in 185 *trawl hauls made during August* 1954, *May to November* 1955 *and May to September* 1956

Species	*Frequency*	Numbers				
		Occasional	*Common*	*Abundant*	*V. abundant*	*V.V. abundant*
		1–10	11–20	21–50	51–100	>100
Portunus sp.	142	25	33	44	24	16
Carcinus maenas	132	15	24	23	53	17
Alcyonidium gelatinosum	126	14	20	49	27	16
Solaster papposus	98	50	24	14	10	–
Flustra foliacea	70	5	16	35	7	7
Pleurobrachia pileus	65	12	17	13	16	7
Asterias rubens	64	24	17	10	12	1
Hyas araneus	40	35	5	–	–	–
Sertularia argentea	28	6	14	8	–	–
Eupagurus bernhardus	23	22	1	–	–	–
Mysids	22	5	13	3	1	–
Aurelia aurita	17	12	3	2	–	–
Halichondria panicea	16	6	4	4	2	–
Siriella armata	13	8	5	–	–	–
Homarus vulgaris	12	12	–	–	–	–
Macropodia rostrata	12	12	–	–	–	–
Alcyonium digitatum	9	5	3	1	–	–
Psammechinus miliaris	8	6	2	–	–	–
Sabellaria spinulosa	7	3	4	–	–	–
Aphrodite aculeata	7	7	–	–	–	–
Haliclona oculata	6	3	1	1	1	–
Aeolidia papillosa	6	5	1	–	–	–
Ophiura texturata	6	1	1	4	–	–
Hyas coarctatus	6	6	–	–	–	–
Cancer pagurus	6	6	–	–	–	–
Praunus flexuosus	5	2	3	–	–	–
Pandalina brevirostris	5	5	–	–	–	–
Ascidiella aspersa	4	3	1	–	–	–
Tubularia sp.	4	4	–	–	–	–
Spirontocaris pusiola	3	3	–	–	–	–
Hippolyte varians	3	3	–	–	–	–
Crangon allmani	2	2	–	–	–	–
Leander serratus	2	2	–	–	–	–
Henricia sanguinolenta	2	2	–	–	–	–
Spirontocaris cranchi	1	1	–	–	–	–
Chrysaora isosceles	1	1	–	–	–	–
Stylarioides plumosa	1	1	–	–	–	–
Tealia felina	1	1	–	–	–	–
Pycnogonum littorale	1	1	–	–	–	–

APPENDIX II

List of Mollusca and Algae, with their frequencies, observed in 185 *trawl hauls made during August* 1954, *May to November* 1955 *and May to September* 1956

Species	*Frequency*	Numbers							
		Occasional 1–10		*Common* 11–20		*Abundant* 21–50		*V. Abundant* >51	
		Live	*Shells*	*Live*	*Shells*	*Live*	*Shells*	*Live*	*Shells*
Sepiola atlantica	79	65	–	14	–	–	–	–	–
Crepidula fornicata	60	3	3	4	16	–	15	–	19
Cardium edule	48	–	5	–	7	–	18	–	18
Alloteuthis subulata	34	28	–	6	–	–	–	–	–
Ostrea edulis	31	7	2	–	12	–	6	–	4
Mytilus edulis	27	–	2	–	4	–	16	–	5
Ocenebra erinacea	18	15	3	–	–	–	–	–	–
Buccinum undatum	17	15	–	1	1	–	–	–	–
Gibbula cineraria	12	5	2	1	4	–	–	–	–
Nucella lapillus	8	4	–	2	1	–	1	–	–
Nucula nucleus	6	1	1	1	–	–	3	–	–
Sepia officinalis	3	3	–	–	–	–	–	–	–
Modiolus modiolus	2	–	–	1	1	–	–	–	–
Macoma balthica	2	–	–	–	–	–	2	–	–
Abra alba	1	–	–	–	1	–	–	–	–
Cardium exiguum	1	1	–	–	–	–	–	–	–
Chlamys opercularis	1	1	–	–	–	–	–	–	–
Petricola pholadiformis	1	–	1	–	–	–	–	–	–
Ensis ensis	1	–	1	–	–	–	–	–	–
Ulva sp.	39	–	–	9	–	22	–	8	–
Laminaria sp.	4	3	–	–	–	1	–	–	–

APPENDIX III

List of fish, with their frequencies, observed in 185 *trawl hauls made during August* 1954, *May to November* 1955 *and May to September* 1956

Species	*Frequency*	Numbers			
		Occasional 1–10	*Common* 11–20	*Abundant* 21–50	*V. Abundant* >51
Agonus cataphractus	129	41	39	33	16
Gobius minutus	90	18	33	31	8
Solea vulgaris	87	76	11	–	–
Clupea sprattus	86	44	6	21	15
Gadus luscus	74	56	6	10	2
Gadus merlangus	54	39	10	5	–
Liparis vulgaris	50	36	8	3	3
Limanda limanda	48	43	3	2	–
Cottus scorpius	47	47	–	–	–
Gobius niger	41	34	5	2	–
Centronotus gunnellus	33	29	3	1	–
Onos mustela	28	28	–	–	–
Raja clavata	28	28	–	–	–
Syngnathus acus	24	24	–	–	–
Pleuronectes platessa	21	21	–	–	–
Anguilla vulgaris	14	14	–	–	–
Zoarces viviparus	10	10	–	–	–
Callionymus lyra	9	9	–	–	–
Gadus callarias	9	9	–	–	–
Pleuronectes microcephalus	7	7	–	–	–
Solea lutea	7	7	–	–	–
Trigla gurnardus	7	7	–	–	–
Trigla hirundo	4	4	–	–	–
Pleuronectes flessus	4	4	–	–	–
Scyllium canicula	2	2	–	–	–
Galeus vulgaris	2	2	–	–	–
Clupea harengus	2	2	–	–	–
Atherina presbyter	2	2	–	–	–
Ammodytes tobianus	2	2	–	–	–
Osmerus eperlanus	2	2	–	–	–
Rhombus laevis	1	1	–	–	–
Trigla cuculus	1	1	–	–	–
Caranx trachurus	1	1	–	–	–

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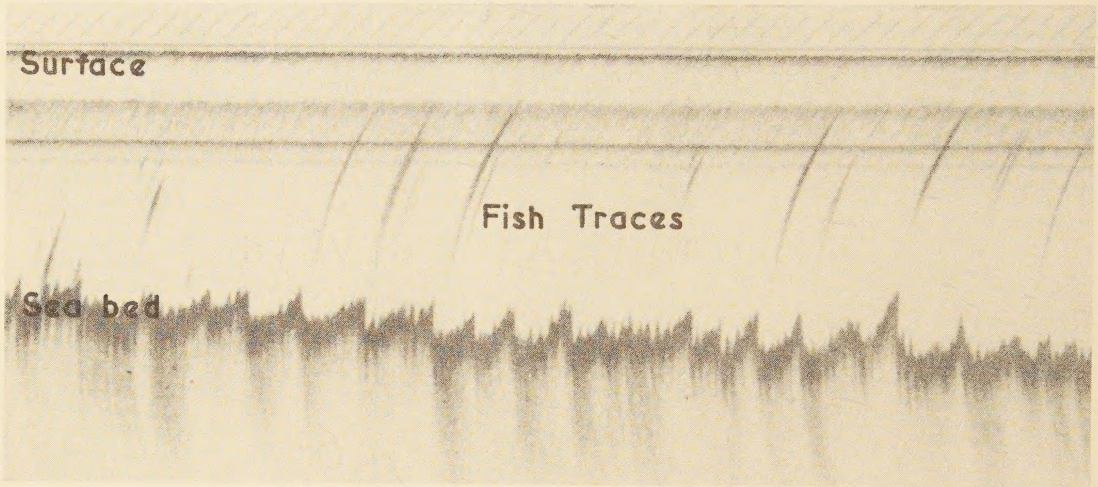

PLATE 1a
Plume Fish Traces

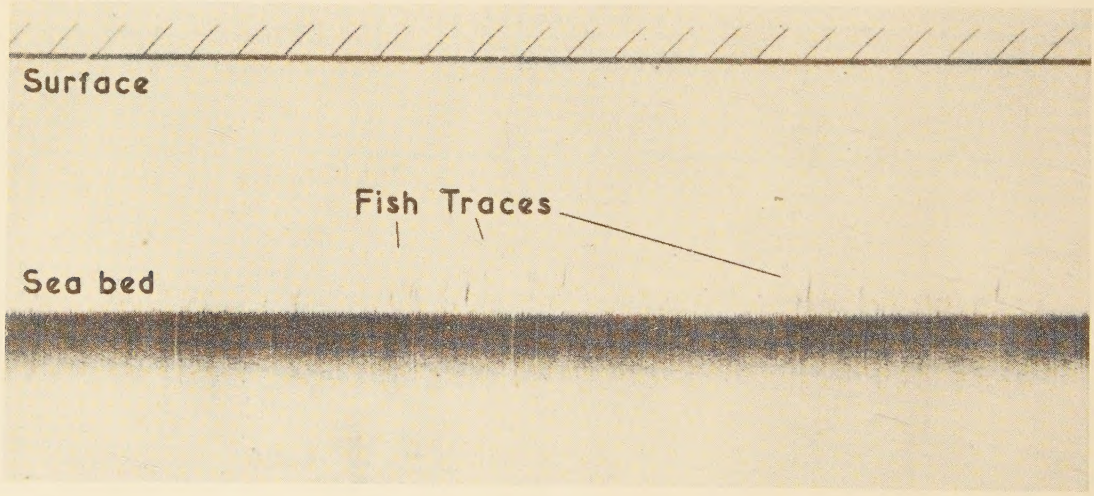

PLATE 1b
Fleck Fish Traces